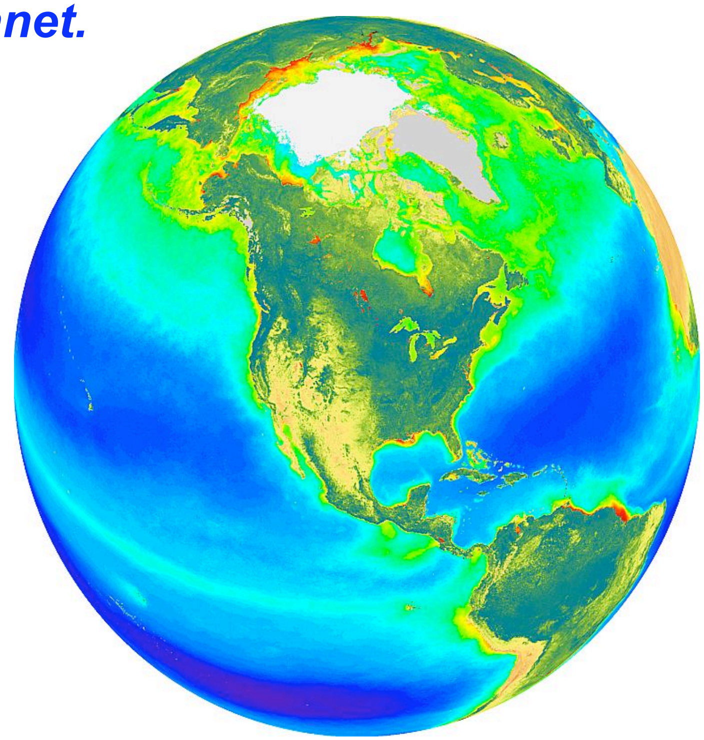
Carbon, Ecosystems, and Biogeochemistry

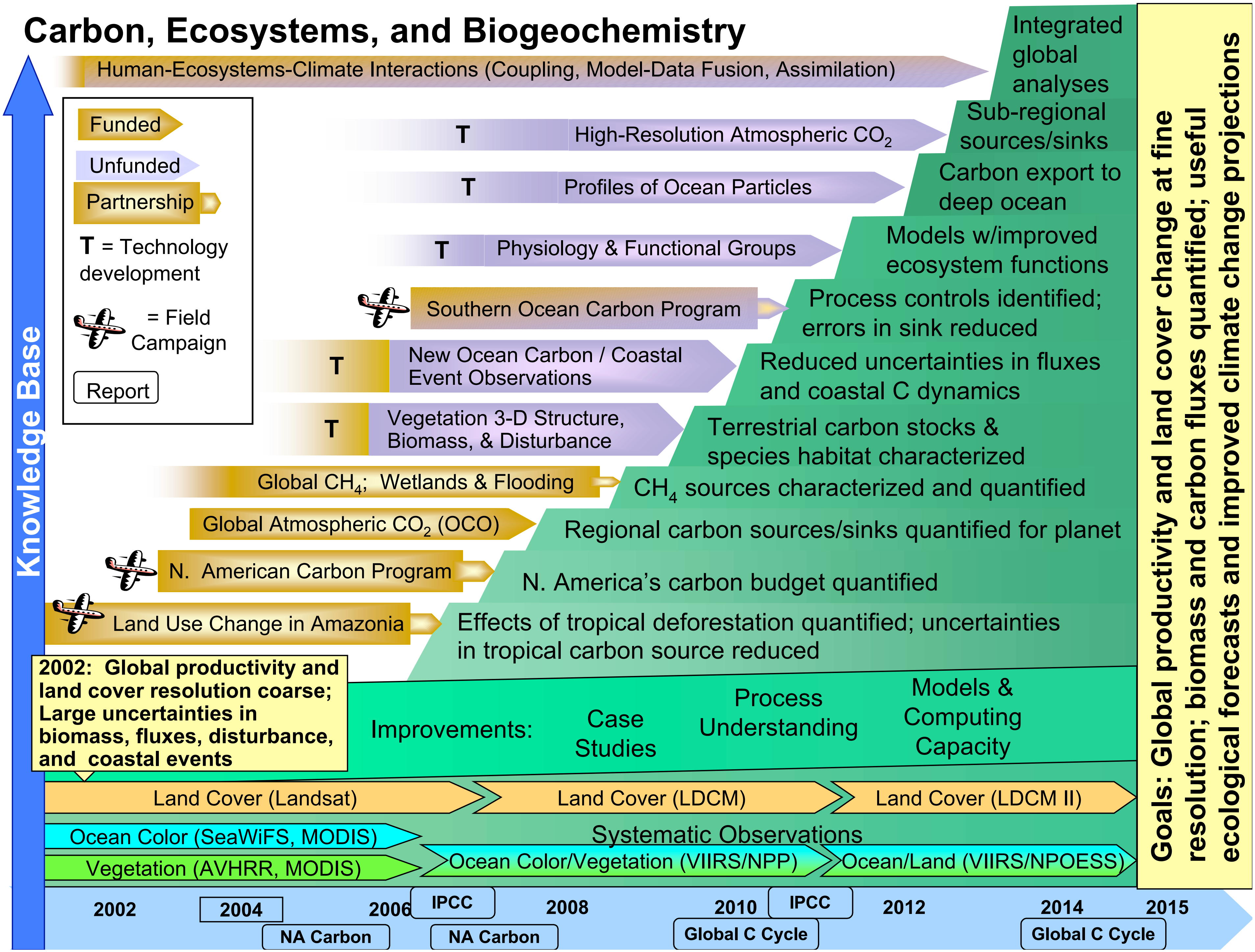
Knowledge of the interactions of global biogeochemical cycles and terrestrial and marine ecosystems with global environmental change and their implications for the Earth's climate, productivity, and natural resources is needed *to understand and protect our home planet.*

Important Concerns:

- Potential greenhouse warming (CO_2, CH_4) and ecosystem interactions with climate
- Carbon management (e.g., capacity of plants, soils, and the ocean to sequester carbon)
- Productivity of ecosystems (food, fiber, fuel)
- Ecosystem health and the sustainability of ecosystem goods and services
- Biodiversity and invasive species



NASA provides the global perspective and unique combination of interdisciplinary science, state-of-the-art Earth system modeling, and diverse synoptic observations needed to document, understand, and project carbon cycle dynamics and changes in terrestrial and marine ecosystems and land cover.



Carbon, Ecosystems, and Biogeochemistry
Human-Ecosystems-Climate Interactions (Coupling, Model-Data Fusion, Assimilation)
Funded
Unfunded
Partnership
T = Technology development
= Field Campaign
Report
T High-Resolution Atmospheric CO_2
T Profiles of Ocean Particles
T Physiology & Functional Groups
Southern Ocean Carbon Program
T New Ocean Carbon / Coastal Event Observations
T Vegetation 3-D Structure, Biomass, & Disturbance
Global CH_4; Wetlands & Flooding
Global Atmospheric CO_2 (OCO)
N. American Carbon Program
Land Use Change in Amazonia
Integrated global analyses
Sub-regional sources/sinks
Carbon export to deep ocean
Models w/improved ecosystem functions
Process controls identified; errors in sink reduced
Reduced uncertainties in fluxes and coastal C dynamics
Terrestrial carbon stocks & species habitat characterized
CH_4 sources characterized and quantified
Regional carbon sources/sinks quantified for planet
N. America's carbon budget quantified
Effects of tropical deforestation quantified; uncertainties in tropical carbon source reduced
2002: Global productivity and land cover resolution coarse; Large uncertainties in biomass, fluxes, disturbance, and coastal events
Improvements:
Case Studies
Process Understanding
Models & Computing Capacity
Knowledge Base
Goals: Global productivity and land cover change at fine resolution; biomass and carbon fluxes quantified; useful ecological forecasts and improved climate change projections
Land Cover (Landsat)
Land Cover (LDCM)
Land Cover (LDCM II)
Ocean Color (SeaWiFS, MODIS)
Systematic Observations
Vegetation (AVHRR, MODIS)
Ocean Color/Vegetation (VIIRS/NPP)
Ocean/Land (VIIRS/NPOESS)
2002
2004
2006
IPCC
2008
2010
IPCC
2012
2014
2015
NA Carbon
NA Carbon
Global C Cycle
Global C Cycle

Anticipated Progress in Answering the Questions:

Forward

Where we are now	Where we plan to be
Global primary productivity and land cover time series available at coarse (~8 km resolution); only short time periods and certain regions at higher resolutions.	Decadal variability in global productivity quantified at moderate (~1 km) resolution; Periodic global land cover change analyzed at fine (~30 m) resolution.
Available observations (*in situ*) of global CO_2, biomass, plant community vertical structure, and species functional groups insufficient to resolve many issues.	New observations (space-based) enable quantification of carbon and nutrient storage and fluxes, disturbance and recovery processes, and ecosystem health.
Large uncertainties in N. Hemisphere terrestrial carbon storage, ocean uptake and storage, and tropical land use effects. Global carbon budget not balanced.	Carbon sources and sinks identified and quantified at sub-regional scales (~100 km), with small errors. Global carbon budget balanced on annual basis.
Ecosystem and biogeochemical cycling models resolve only very large year-to-year variations; multiple controlling processes not well quantified or modeled.	Earth system models able to correctly portray most interannual variations and the multiple, interacting processes that control them, with sub-regional specificity.

2002 → ~ 2015

Anticipated Outcomes and Uses of Results

Predicting Carbon Cycling

Result / Capability	Products / Uses for Decision Support
Global primary productivity and land cover change time series variability and trends quantified at moderate to fine spatial resolution. Carbon sources and sinks identified and quantified.	Quantitative global **monitoring & evaluation tools**: to assess the efficacy of carbon management (e.g. sequestration in biomass); to assess agricultural, forest, and fisheries productivity; to verify emissions and/or sequestration reporting by nations/sectors.
Quantification of carbon and nutrient storage and fluxes, disturbance and recovery processes, and ecosystem health. Quantification of controlling processes and their interactions.	**Maps, data products and information** on relationships among them as input for decision support systems. Simulation models that enable “If … , then…” scenarios to be explored.
Models that: - achieve carbon balance - reliably characterize interannual variability and sub-regional processes - quantitatively portray multiple, interacting controlling processes - are able to correctly simulate past land cover, ecosystem dynamics and biogeochemical cycling	**Ecological Forecasts**: Projections of changes in carbon sources and sinks, land cover, and ecosystem dynamics due to combinations of real-world forcings of global environmental change with sub-regional specificity and good reliability for ~6 mos. to 2 years into the future (e.g., harmful algal blooms, invasive species). --- **Inputs for Climate Projections**: Credible, useful projections of future climate change (including improved ecosystem feedbacks and projections of CO_2 and CH_4 concentrations) for 50-100 years into the future for a variety of policy-relevant “if …, then …” scenarios.